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Project Report

ETS-24

A Users Guide
to the GEODSS Real-Time System

S. N. Landon

1 November 1977

Prepared for the Department of the Air Force
under Electronic Systems Division Contract F19628-78-C-0002 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS



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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

A handwritten signature in dark ink, reading "Raymond L. Loiselle". The signature is written in a cursive style with a large, stylized 'R' and 'L'.

Raymond L. Loiselle, Lt. Col., USAF
Chief, ESD Lincoln Laboratory Project Office

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

A USERS GUIDE
TO THE GEODSS REAL-TIME SYSTEM

S. N. LANDON

Group 94

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ABSTRACT

The following guide describes the GEODSS Real-Time and simulated system from the standpoint of the operator. Included are descriptions of system messages, operator inputs and options, and error conditions and recovery procedures. Much of the system is controlled by programmable buttons, and diagrams of their locations and functions are included in the appendix.

The Real-Time System runs on a MODCOMP IV computer with 128K of core. It gives the operator control of one of two 31-inch optical telescopes in the automatic search/track or manual modes. The automatic modes are used for locating and tracking satellites. To aid in finding them, various scan patterns are available, which may be superimposed on the basic tracking of the telescope. The operator may also control the telescope manually at rates ranging from a few seconds of arc to four degrees per second. Calibration and calibration checking are two other features of this system. Magnetic tape recording, line printer output and a metric observation file log the metric data. Target identification assistance is provided by a program that lists all known satellites within five degrees. A satellite scheduling program may be used to automate scheduling. An SOI data collection capability is also available.

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I. REAL-TIME SYSTEM STARTUP PROCEDURES

The following startup procedures must be followed at the telescope console, on the computer and in the dome before Real-Time System operation may begin.

At the telescope console:

Turn on the power to all console devices and monitors.

Select the ADDS (System CRT) at one or more monitors.

Select video output from the camera on one or more monitors.

Set the digitizer select buttons to the ADDS or camera output.

At the computer:

Turn on the power to the computer, the peripherals and controllers.

Set the I/OIS switch to the desired telescope.

Set the peripheral switch to the machine which will use the line printer first.

Then bring in the system on the computer:

Hit the three switches on the lower left side of the console panel in the following order:

Master Clear, Fill, Run

The computer will respond by printing a line on the teletype.

Then enter M04 for the double disc system or M05 for the single disc system.

After a number of seconds, the computer will respond with 'SATISFIED'.

Enter GO (or G).

The computer will then complete its initialization and type a number of messages.

When it has finished printing, depress the console interrupt switch on the panel (the lower right switch) and enter the following at the teletype:

/RTS/ACT,,TM

In the dome:

Turn on the cameras.

Turn on the power switch on telescope panel.

Enable the computer to drive the telescope and the dome by setting the appropriate switches.

II. SYSTEM INITIALIZATION

Once the command has been entered at the computer teletype to start up the system, the following message will appear on the system CRT terminal, the ADDS:

GEODSS SYSTEM, VERSION 2.4, MAX IV, ONLINE 10/11/77

TYPE TITLE

The computer then expects an operator-entered title. The title may be of any length up to 72 characters. The title may contain any alphanumeric information necessary for session identification.

Once the title has been entered, the mode of operation is requested:

SELECT MODE

REAL TIME (1) SIMULATED (2)

A '1' selects the real-time option in which the telescope is driven by the computer. A '2' selects a mathematical simulation of telescope motion. Under that option, the telescope is not driven even if it is available. All system data - including the LED displays and printouts - will reflect the simulated motion of the telescope. This system may therefore be used for the training of operators during the day or for the checkout of program development when the actual telescope is not required.

Following the determination of the type of run, the system asks the operator whether the Dynamic Satellite Scheduling program is to be run:

RUN DYNAMIC SCHEDULER? (YES OR NO)

If the user responds with a 'YES', the Dynamic Satellite Scheduling program is activated. Otherwise, nothing is done. The computer then

asks the user to select a pointing task with which to initialize the system.

SELECT POINTING TASK

SATELLITE EPHEMERIS (1) FIXED POINT (2)

The user makes a selection, and the program corresponding to the function required is brought in. The details regarding the inputs required will be discussed under pointing data. In the case of a satellite, a satellite number is requested. The Fixed Point program requires the right ascension and declination to which the telescope is to be driven.

Following the initial selection of a pointing position, the system must determine whether magnetic tape recording is to be done.

SELECT TAPE DRIVE

NONE (0) MT1 (1) MT2 (2)

The desired drive (1 or 2) should be specified at this time. Entering a '0' will suppress magnetic tape recording until the first push of the metric data button at which time the program will assume that a tape is available on drive 1.

Following the selection of the tape drive, a start time is requested. The following prompting message appears:

ENTER START TIME (NOW) OR (HOURS,MIN,SEC)

Either 'NOW' or a start time may be entered. Once the time is reached, the system begins running.

The telescope remains stopped when the system begins in the event that a calibration is to be done. In that case, the telescope's remaining

at the current location may be important. Regardless of what function is to be performed first, the operator must turn off the STOP button in order that the system be able to drive the telescope to the desired location.

Once the system begins running, the LEDs are updated once a second, and information is recorded on magnetic tape if that option was selected.

III. SELECTION OF TELESCOPE POINTING DATA

As described in Section I, the system operator must select a pointing program - either the Satellite Ephemeris or the Fixed Point - during system initialization. There is in addition one other pointing program, the Calibration Check program. This program is not available at initialization time. Each of these programs provides pointing data for the telescope. These programs may be brought in at any time during the running of the system by the operator pushing the button corresponding to it. See Appendix A for the location of the three buttons - SAT EPH, FIX PT and CAL CK - which select the three pointing functions. Whenever these programs are brought in at non-initialization time, they will be prefaced by a message beginning 'MODIFICATION' and terminated by a 'MODIFICATION COMPLETE' message.

A. Satellite Ephemeris

When the Satellite Ephemeris program is called in, the following message appears on the ADDS at the telescope console:

MODIFICATION - SATELLITE EPHEMERIS

SATELLITE <&RA, &DEC, &TIME>

When this message appears, the computer is expecting the operator to enter the satellite number of interest optionally followed by positional and time offsets. If the offsets are entered, they will not be added to the pointing data until the SCAN button is pushed on the console.

If the operator responds to this request for input with a \$\$, the previous satellite selected will be used.

Once the number has been entered, the program will search the system satellite file for the desired satellite. If it is not found, a message will appear to that effect, and the operator will have another opportunity to enter a satellite number.

When the satellite is found, the system will print out its element set and various information about its satellite. This information includes the type of payload, the sun angle, and whether this satellite has been observed since the last time the elements were updated.

Providing that this is not a system initialization run, the
MODIFICATION COMPLETE
message will then appear, signalling the end of this program. The button light will be concurrently turned out.

B. Fixed Point

When called in, the following message appears:

MODIFICATION - FIXED POINT

SELECT TYPE OF INPUT

RA,DEC (1) AZ,EL (2)

This program will drive the telescope to either a fixed right ascension and declination or to a fixed azimuth and elevation. The operator must therefore first indicate which type of pointing is desired.

If a '1' is entered, the computer next requests the pointing right ascension for the telescope:

ENTER RA (HOURS,MIN,SEC)

The operator must then enter three digits in free format - that is, at any position on the line. These quantities are checked for validity. If any are missing or out of range, the question is repeated.

Once an acceptable right ascension has been obtained, the declination is likewise sought:

ENTER DEC (DEG,MIN,SEC)

Three digits are again required. The minus sign if entered should be affixed to the degrees digit. Validity is checked as in the case of right ascension; the user is prompted again if the input is incorrect.

Once both the right ascension and declination have been obtained, the

MODIFICATION COMPLETE

message appears, signalling the termination of this program. The button light is also turned off.

If a '2' is entered for the type of input, the computer requests an azimuth and an elevation. Azimuth is requested first.

SELECT AZIMUTH (DEGREES)

A floating point azimuth is then accepted. The decimal point may or may not be specified. If digits are supplied to the right of the decimal point, they will be used. If the azimuth is less than zero or greater than 360, the request is repeated.

The elevation is next obtained:

SELECT ELEVATION (DEGREES)

A floating point elevation is then expected. The decimal point and following digits may or may not be present. The elevation is checked for validity, and the operator must enter it again if it is incorrect.

Once the computer has obtained a reasonable azimuth and elevation, the message

MODIFICATION COMPLETE

appears on the ADDS as in the right ascension and declination case. The button light is turned off.

If a \$\$ is entered at any time while this program is running, the program will exit without changing the telescope pointing data.

C. Calibration Check

This program drives the telescope to six bright stars in reasonable proximity - i.e., five degrees - to the current position of the telescope. This program assumes that a Satellite Ephemeris program has immediately preceded it. The purpose of the Calibration Check program is to provide local calibration information so that the satellite metric position may be corrected.

This program reads the SAO star disc and finds six stars of visual magnitude seven or brighter that are close to the current position of the telescope. It then finds the closest star and drives the telescope to that location. The coordinates and visual magnitude of the star are written out on the ADDS screen, and the operator is prompted by a message on the terminal to manually boresight the star and to push the calibration button (CALIB POS; see Appendix A for its location) when the star is on boresight.

When the button is pushed, the computer calculates the difference between the predicted and actual star positions to obtain the calibration error. Once this calculation has been done, the results are saved and the telescope is driven to the closest star of the five remaining.

Coordinates and a prompting message are again printed. An example of that message is the following:

RA = 19 39 1 DEC = 17 57 28 MAGNITUDE = 4.30

PUSH CALIBRATION BUTTON WHEN STAR IS ON BORESIGHT

When all six stars have been processed, a table containing the differences between the predicted and actual positions of the stars is displayed.

The average differences are also printed out.

Following the printout of this table, the system automatically restarts the previous pointing task - which is assumed to be the Satellite Ephemeris task.

IV. SYSTEM CALIBRATION

System calibration consists of the setting of the right ascension, declination and hour angle registers on the telescope to those of a calibration star. This is done by driving the telescope to a star, boresighting the star and invoking the system calibration procedure which sets the telescope registers.

The operator must first push the calibration (CAL) button. When that button is pushed, the following message appears on the ADDS terminal:

MODIFICATION - CALIBRATION

ENTER 'GO' TO CALIBRATE, \$\$ TO EXIT

The operator may enter a \$\$ if the button is pushed by mistake. If something other than a \$\$ or 'GO' is entered, the input is requested again.

If a 'GO' is entered, the system then checks to see that a Fixed Point is the current pointing program. This is to ensure that the telescope is at a star and that the data that the Fixed Point program provides to the Calibration program is available and current. If the Fixed Point is not the current pointing task, the program prints the following message and exits:

FIXED POINT PROGRAM IS NOT CURRENT POINTING TASK - EXITING

If the Fixed Point task is the current pointing task, the program prints the following on the ADDS:

PUSH CALIBRATION BUTTON WHEN STAR IS ON BORESIGHT

The CALIB POS button must then be pushed when the operator has boresighted the star. The right ascension, declination and hour angle registers of the telescope will then be changed to those of the calibration star.

The MODIFICATION COMPLETE message will appear at the completion of this function. Also, the lights on the CAL and CALIB POS buttons will be turned off at this point.

V. TELESCOPE CONTROL MODES

The entire system and particularly the telescope is controlled by programmable buttons. Those buttons are backlighted when the function in question is being performed. The Telescope program responds to sixteen buttons. Those buttons offer modes of manual control as well as other functions.

A. Manual Telescope Control Options

The telescope is controlled manually by a 'joystick' which may be displaced by the operator. The position of the joystick is digitized and read by the computer. That joystick position is then used by the computer to drive the telescope under operator control. The programmable buttons provide options to the user which provide for a greater variety of functioning than the simple use of the joystick alone would offer.

1. Variable rate telescope control using the joystick. The pushing of the button labelled COARSE on the console (see Appendix A for button locations) enables the joystick/manual mode. If this button has not been pushed, then the TRACK button light will be on, indicating that the telescope is being driven by the pointing output from the Main Pointing Sequence. One of these two buttons will be on at all times, and no more than one of them will be on at a time. If two of them are lit, it will indicate that the Telescope program has stopped running.

The COARSE mode of joystick control sends out rates which are scaled from zero to the maximum variable rate that the telescope can reach - 3000 arc seconds per second. Maximum displacement of the joystick

should produce a 3000 arc second per second rate in the direction in which the joystick is displaced. The X axis is the right ascension axis, and the Y axis is the declination axis. The axes may be driven separately or together, depending on the position of the joystick.

2. Slower variable rate control using the joystick. Because the joystick does not offer any more than 100 possible digitized values and because the telescope may be driven at any 4000 different rates, two other buttons are provided which offer more precise movement of the telescope in response to the movement of the joystick. Those buttons are labelled MEDIUM and FINE. The MEDIUM rate varies between zero and a maximum of 300 arc seconds. That is, it is an order of magnitude lower in range than the COARSE rate. Note that the COARSE button light must be on when the MEDIUM or FINE rate is in use because the COARSE button enables the joystick mode. The FINE button allows the joystick to drive the telescope at rates between zero and sixty arc seconds. The maximum rate of the FINE button is a factor of five slower than the MEDIUM one. If the telescope is in the TRACK mode, the MEDIUM and FINE buttons will have no effect.

3. Slewing with the joystick. Provided that the COARSE button is on - i.e., that the joystick mode is enabled, pushing the SLEW button causes the telescope to drive at fixed rates of four to five degrees per second in the direction or directions in which the joystick is displaced. Because of the rapid rate at which the telescope is traveling in this case, a large inactive region is left around the

joystick. Thus, small displacements of the joystick will have no effect. The joystick must be very significantly moved in the desired direction or directions in order that the telescope be slewed in that direction.

4. Inverting the direction of right ascension travel for the joystick. Because of the difference in the direction in which the stars travel relative to the viewer when the telescope is in the second quadrant, a button has been provided which will change the direction in which the joystick applies rates on the right ascension axis. This allows the apparent response of the telescope to the joystick to remain the same once the telescope has passed the north pole.

5. Rate joystick. The turning on of this button in conjunction with the COARSE (joystick enable) button causes the telescope to interpret displacement of the joystick differently. The nominal joystick mode drives the telescope at a rate proportional to the displacement of the joystick. The rate mode adds to or subtracts from the rate of the telescope at a rate proportional to the displacement of the joystick. Returning the joystick to the central null position will thus not stop the telescope but will merely cease adding to or subtracting from the rate. This mode is useful in developing a rate for an unknown satellite.

6. Joystick rate saving. If the joystick is being used to develop a rate for an unknown satellite, this rate may be saved. It should be noted that either the nominal joystick mode or the rate joystick mode may be used to obtain the rate, whichever is more convenient for the operator. Once the rate has been obtained, the JOY RAT SAV button

should be pushed. That rate will be retained until the next time that this button is pushed.

7. Joystick rate restoring. Once a joystick rate has been saved, the operator can boresight the satellite. To return to tracking the satellite, s/he must push the JOY RAT RSTR (Joystick Rate Restore) button. This should always be done in the joystick mode, (i.e., with the COARSE button on). Pushing this button will have no effect in the TRACK mode.

8. Select offset with joystick. When a satellite has been found for which the orbital elements are on file and which is not on boresight, all that is required is that an offset be entered into the system so that the target may be tracked on boresight. The joystick may then be used to bring the target on boresight. The target should then be left there for a second if possible; this is not mandatory. The operator should then push the SELECT OFFSET button. That button will store the difference between the current telescope position and the ephemeris calculation. The operator may then turn on both the ADD OFFSET and TRACK buttons. That combination will cause the satellite to be tracked at boresight by adding in the constant offset which was selected by the SELECT OFFSET button.

9. Stopping the telescope. The telescope may be stopped at any time by the operator by pushing the button labelled STOP. This will take affect regardless of whether the telescope is in the TRACK or the joystick mode. Stopping the telescope consists of putting it into

sidereal drive - that is, of stopping the declination axis and driving in right ascension at a rate of 15 arc seconds per second. No other mode of telescope control can override this one.

10. Rate calibration. Because the components in the telescope drive logic are temperature sensitive, the null (stopped) position of the telescope fluctuates. A manual procedure for re-calibrating has therefore been provided. The operator should first use the joystick to stop the stars. When the sidereal rate has been obtained by that method, the operator should push the CAL RATE button. That button will set the null position of the telescope to the value of the current rates. Once this has been done, no drift should be observable when the joystick is enabled but not displaced in any direction. A periodic check on this should be done. If the telescope is drifting noticeably, the calibration procedure should be performed.

11. Rate freeze. At any time, this button may be pushed. It will cause the telescope to continue tracking at the current rate until the button is turned off. Only the STOP button will override it.

B. Additional Telescope Control Options

A number of additional telescope control features are available. They are all available by the pushing of a programmable button.

1. Low elevation override. Normally, the software will not allow the telescope to be driven below an elevation of ten degrees. This is a safety measure. A mechanical stop in the telescope will also stop it shortly below ten degrees so that the telescope mirror will not

move out of place. In any case, at times there are important targets which are below ten degrees. There is an ELEVATION OVERRIDE button which changes the software limit from ten degrees to three degrees. As this means traveling through the mechanical stops on the telescope, driving the telescope below ten degrees requires that someone be in the dome pushing the mechanical override button also.

2. Mark data as metric data point. If the Target-on-Boresight button is pushed, the data is marked as metric. It is printed on the line printer, recorded on magnetic tape and written onto the observation disc file.

3. Diagnostic printout button. If this button is pushed, diagnostic printout containing information on the driving of the telescope will appear on the line printer. This printout can be useful in troubleshooting telescope driving problems. As a large quantity of printout is generated, the button should never be left on for more than a minute.

VI. SELECTION OF SCAN PATTERNS

Two types of scan patterns are available in this system. One is a box scan in right ascension and declination about a specified point, and the other is an along orbit scan which assumes that the current pointing task is the Satellite Ephemeris. These patterns may be entered by pushing the appropriate button. The button labelled ALONG ORBIT generates the along orbit scan while the SEARCH button sets up the parameters for the box scan.

Both types of scan require input from the operator on the system CRT, the ADDS. Each request for input is preceded by a message of the form - 'MODIFICATION'. The input is terminated by a MODIFICATION COMPLETE message.

Finally, several buttons are available for scan control. Their functions are as follows.

1. SCAN - This button initiates the scan. Unless the button is pushed, no scanning will be done. Turning it off terminates the scan.

2. HOLD - The current scan offsets are held until the button is turned off.

3. LAST FOV - The scan returns to the last field of view in the scan.

4. INTEGRATE - This button is intended for use with an integrating camera. Instead of stepping and stopping in sidereal drive, the telescope steps and then resumes tracking at the rate predicted by the ephemeris. In this case, the satellite will be the only stopped object on the screen, and integration should be able to aid in its detection.

5. QUERY SCAN - This button gives the operator information about the current progress of the scan. The line number, box number, and an estimate of the total and remaining time to complete the scan are given.

A. Along Orbit Scan

The following message appears on the ADDS when the ALONG ORBIT button is pushed:

MODIFICATION - ALONG ORBIT SCAN

EXTENT(MINUTES), STARE(SECONDS), FOV(DEG), OFFSETS(&RA &DEC &TIME)

The operator must then input the number of minutes along the orbit that the scan is to cover, the number of seconds that the telescope is to stop at each field of view, the field of view of the telescope and (optionally) right ascension, declination and time bias offsets. (Units are degrees for right ascension and declination and seconds for time.)

The pattern will be overlapped so that there are no missed portions of the sky within the pattern. The scan will, however, not be initiated until the SCAN button is pushed.

B. Box Scan

When the SEARCH button is pushed, the computer prints the following on the ADDS terminal:

MODIFICATION - SEARCH

STARE(SECONDS), STEP(DEG), TYPE(RA/DEC(1), DEC/RA(2))

The number of seconds for which the telescope is to stop at each field, the number of degrees to step between fields of view and the type of scan is requested. If the scan type is RA/DEC, the telescope will move

first in right ascension; conversely, if the scan type is DEC/RA, it will first move in declination.

Once this input has been obtained, a second message appears:

SIZE: RA, DEC, SPACE BET. LINES(DEG)

The box size in right ascension and declination is requested as well as the number of degrees to be traversed by the telescope between lines.

The final input concerns offsets that are to be added to the pointing position before centering the box.

OFFSETS: RA(DEG),DEC(DEG),TIME(SEC.)

These offsets are optional; a zero should be entered if no offsets are desired.

The program now has sufficient information with which to construct the box. It will print out the actual step size between fields of view and between lines. The program modifies the user input to ensure overlap. Also, the estimated time to complete the pattern is printed out.

Finally, in both cases, the MODIFICATION COMPLETE message appears, and the button light is turned off.

VII. AUTOMATED SYSTEM SCHEDULING

A dynamic satellite scheduling program is available. At system initialization time, the operator may elect to run with this program or not. Provided that the operator has elected to use it, pushing the SCHEDULE button will allow the operator to schedule the next satellite to track.

When the scheduling program first runs, it prints out the file of satellites that are to be scheduled. That file is constructed during the day and is stored on a disc partition.

To signal that the program is ready to accept input, an arrow is typed on the ADDS:

==>

The operator may then enter commands. The most likely is 'GO'. That command asks the program to suggest the best target. A variety of criteria are used to make this choice. These criteria include tasking priority, distance between the satellite and the current telescope position, rise and set times of the targets and sun angles.

The suggested target number and its element set are then printed out on the ADDS. If the operator wishes to drive to that target, s/he must push the SAT EPH button (see Section II) and enter the satellite number.

If a target that is scheduled by this program is not found, on the next entry to this program, the program will turn on the alarm button (which has both a light and an audible warning) and request the entering

of a 'Miss Code'. That code is used to identify the reason(s) that the target was not found. These Miss Codes are stored by the program and printed out at the end of the evening.

The 'EXI' command, which is usually issued at the end of the evening, will print a list of the targets attempted and the Miss Codes for those which were not found.

VIII.A TARGET VERIFICATION AID

A program known as the Vector Element Comparison program computes the positions of all satellites on the satellite file which are within five degrees of the current pointing position of the telescope. The satellite numbers, positions, distances and velocities appear in tabular form. The satellite which most closely matches the current position of the telescope is noted. If that satellite number differs from the one currently in the pointing program, a warning message appears and the alarm bell is turned on. If no satellites are present within five degrees, a message appears to that effect.

This program is invoked by the pushing of the VEC button on the console. There is no input required from the operator. This program will run perhaps 15 seconds. Thus, there will be a delay between the printing out of the title and the appearance of the entries below it.

The program will terminate with the message VEC COMPLETE. The button light will be turned off at that time.

IX. THE RECORDING OF SYSTEM DATA

Data from the Real-Time System is recorded in a number of places and in a number of ways. A description of each follows.

A. Line Printer System Log

All of the transactions that take place at the ADDS terminal are printed on the line printer. For the moment, that is the only permanent record of those transactions. Later, it will also be available on the magnetic tape.

Other data also appears on the printer. Error messages are routed to both the ADDS terminal and the line printer. Occasionally, programs (such as the scan program) will print informational messages on the line printer only so as not to distract the system operator.

The remainder of the data that appears on the line printer is selected by the operator. In most cases, this consists of the metric data points taken on satellites. Whenever the Target-on-Boresight button is pushed, a message appears indicating that. Also, the current position and rates of the telescope are printed out. Another button, the RECORD button, prints the position and rates of the telescope on the printer but does not mark the data as metric.

One final type of printout occurs on the line printer and the line printer only. That is the operator's comments. Whenever the ADDS terminal is not occupied with other transactions, the cursor on the ADDS will move to the next line, signalling that the operator is free to enter comments. Those comments will automatically appear on the line printer. In the future, they will also appear on magnetic tape.

B. Magnetic Tape Recording

Magnetic tape recording is optionally provided by the Real-Time System. At system initialization time, the operator indicates the tape drive that is to be used. If no drive is to be used, no recording is done. It should be noted that all of the message sending capability to Space Defense Center is currently based on data recorded on magnetic tape; therefore, magnetic tape recording will be done whenever the metric (Target-on-Boresight) button is pushed. If no tape drive has been selected, drive 1 will be assumed. When the observation file has the message capability, this practice will be discontinued.

There is a button associated with the magnetic tape recording program. That button (marked MAG TAPE REC) may be turned on and off by the operator. When on, system data will be recorded on tape each second. That data contains time, telescope position, current satellite number, system button settings and diagnostic information.

C. Observation File on Disc

Each time that the metric (Target-on-Boresight) button is pushed, data is recorded on the system observation file. This file contains only the satellite number, time and telescope position. Four metric points spaced three seconds apart are written onto disc. That spacing of data reflects the current requirements on the GEODSS site from Space Defense Center.

The data file remains intact between runs of the Real-Time System and therefore may be used to collect a week's worth of data. As

the disc partition on which this data resides is reasonably small, only 1200 sets of data may be stored there. When the partition is full, a message will appear on the ADDS screen, and recording on the disc will be discontinued. The file may be erased by an offline program when the contents are no longer needed.

D. Satellite Offset Saving

Whenever the Target-on-Boresight button is pushed, the satellite offsets for the current target are updated. The disc file containing the satellite elements also contains one set of offsets for each satellite. These offsets are replaced when metric data is taken. At that time, the offsets stored and the time at which they were taken appear on the ADDS terminal as a confirmation of the storing of the new offsets on the file.

E. SOI Data Collection

The taking of SOI data on a satellite is initiated by the pushing of the SOI button. When that button is pushed, SOI data will be collected 30 times a second and written onto magnetic tape once a second if the tape recording is on. The data is also plotted on a strip chart.

X. SYSTEM REINITIALIZATION AND SIGNOFF

At any time following the completion of system initialization, the operator may either reinitialize the system or sign off from it. Both of these functions may be initiated by the pushing of a single button on the console. That button is labelled INIT/SIGNOFF and when pushed generates the following message on the ADDS terminal:

```
SELECT FUNCTION: REINITIALIZE(1) SIGNOFF(2);$$=ESCAPE
```

The operator may then elect to reinitialize, sign off or to escape. The escape option has been provided in the event that the button is pushed accidentally.

If either a '1' or '2' is typed in, verification of operator intent is requested. The following message is written on the screen:

```
PLEASE VERIFY
```

```
SELECT FUNCTION: REINITIALIZE(1) SIGNOFF(2);$$=ESCAPE
```

The input must then be repeated. When entered for a second time, the requested function is performed by the system.

A. System Reinitialization

A system reinitialization consists of a system signoff followed by a system initialization. The system is stopped, and all programs are removed from memory. The initial title is printed out along with the message - EXPERIMENT TERMINATED.

Within a few seconds of the appearance of the EXPERIMENT TERMINATED message, the screen is cleared, and the system initialization message appears:

TYPE TITLE

System initialization then proceeds as described in Section II.

B. System Signoff

When system signoff is indicated, all of the programs are stopped and removed from memory. Finally, an end of file is written onto magnetic tape and a few system utility programs are started up. These include a LED display program which perpetually displays the time and telescope position on the telescope console LEDS and a microprocessor interface program. Abort messages from several tasks appear on the ADDS at the end. Interspersed among these three or four messages are the original title and the message

EXPERIMENT TERMINATED.

XI. ERROR MESSAGE AND CONDITIONS

Error messages and conditions may be generated by many different parts of the system. They are grouped by area for the purposes of this discussion.

A. Data Errors on Operator Input

Whenever operator input is requested on the ADDS, that input is checked for validity. If the data is not correct, the operator is requested to input the data again.

B. System Setup Error Messages

These messages could occur during system initialization and if present, they would point to a serious condition that would require programmer intervention to ameliorate. Following are samples of the type of messages that could appear:

ERROR IN ACTIVATING DYNAMIC SCHEDULER...CODE='n'

ERROR IN CONNECTING TIMER...CODE='n'

ERROR IN THAWING TIMER...CODE='n'

ERROR IN LOVER - CODE='n'

TASK'name'NOT ESTABLISHED

The only error from which recovery is possible is the ERROR IN CONNECTING TIMER. If the problem is caused by the inability of the program to read the GMT clock data or to obtain reasonable clock data, then by fixing the clock, the system will function. Generally, if this is the case, messages regarding the problem with the clock data will accompany it. See subsection G.2 for data on clock errors.

Instances of seeing these messages are, obviously, exceedingly rare.

C. Alarm Button Conditions

When a condition occurs which requires operator action and which indicates a probable error, the alarm button is turned on. An audible alarm is produced by the backlighting of this button. The operator should push the alarm button in order to turn it off and then perform the necessary corrective action.

Following is a list of conditions under which the alarm button will be turned on.

1. Target below Horizon - If the predicted target location is below 15 degrees elevation, the alarm will be turned on. Also, the TARG BELOW HORIZ button will begin flashing. The operator should in this case stop the telescope and select a target which is above the horizon.

2. Telescope below 15 degrees - This warning allows the operator to stop the telescope before it hits the ten degree software limit on the elevation of the telescope.

3. Vector Element Comparison program warning - If the satellite which is computed to be closest to the current sensor position is not the satellite last entered into the system, the alarm button is turned on. This should alert the operator to check more closely on the identity of the object.

4. Dynamic Scheduler - The last target has not been found. A "Miss Code" must be entered.

D. Overflow of Observation File

If the observation file on disc is full, when the Target-on-Boresight button is pushed, a message will appear, and further data recording will be discontinued. The message reads as follows -

END OF OBSERVATION DISC SPACE - RECORDING STOPPED

The message will only appear the first time that the disc is discovered to be full during a given run of the Real-Time System. No operator action is required. Provisions should be made, however, the next day to make disc space available to the program.

E. Modification Task Swapping Errors

When the Satellite Ephemeris (SAT EPH), Fixed Point (FIX PT), Calibration Check (CAL CHK), ALONG ORBIT or SEARCH buttons are pushed, the Real-Time System may have to remove one program from memory and bring in another in its place. Should a failure occur in this process, a message will appear. These messages should not occur. A programmer should be consulted if one is seen. It is doubtful if the system would be able to run in the event that one occurred.

OLD POINTING TASK NOT DEESTABLISHED

IS1=n ITRK=n

NEW POINTING TASK CANNOT BE ESTABLISHED

OLD SCAN TASK NOT DEESTABLISHED, INDEX=n

NEW SCAN TASK NOT ESTABLISHED, INDEX=n

ERROR IN LOVER, CODE=n

F. Vector Element Comparison Error Message

This program checks the element sets of the satellites on file before using the element sets to compute the current position of those satellites. If an error is found, a message will appear on the ADDS screen.

INVALID ELEMENTS FOR SATELLITE#xxxxxxx.x

The message will flash so as to catch the operator's attention.

G. Errors in Interface Hardware Data

The Real-Time System software is dependent in a major way on the successful and relatively error-free functioning of the numerous hardware interfaces from which it obtains and sends data. The error messages regarding the interfaces are therefore grouped by hardware function.

1. Buttons Channel. There is only one message produced by an error in button data. The message reads -

UNABLE TO INITIALIZE BUTTONS CHANNEL

It is a serious message as it indicates that the program is unable to communicate properly with the buttons. Since the Real-Time System functions primarily from these buttons, the system would be inoperable in such a case. This message is extremely unlikely to occur. The failure to turn the power on to the I/OIS would be the most likely cause of the message, and that is easily corrected.

2. GMT Clock. The system requires clock time which is read from the Datametric clock via hardware interfaces. Despite its dependence

on time, the system is reasonably well protected against failures in the clock hardware. The messages that are described below are therefore warning messages that should be used to report failures to the hardware maintenance people. The software will switch to internal computer time when the GMT clock data is unavailable or unreliable. That time is not as exact as the other, but the degradation is not severe.

The messages that may appear are the following:

20 CONSECUTIVE BAD STATUS BITS FROM CLOCK

ERROR IN ID BITS OF CLOCK INPUT

RANGE OF CLOCK DATA INCORRECT

The first message indicates that the clock may not be read at all as the hardware keeps signalling the computer that the data is changing and should not be read. The data changes swiftly; this message indicates a problem in the interfaces.

If the first four bits of the data that the computer reads from the clock is not in the prescribed format, the program detects it and issues a message. It then prints all of the clock data that has been read. The data should be shown to a hardware maintenance person.

The range of the clock data is checked by the program. Hours should not exceed 23; minutes and seconds should not exceed 59. If these checks fail, the data is unreliable and will not be used. Again, the error printouts should be shown to someone in the hardware maintenance area.

3. Positional Joystick. The positional joystick provides the means by which the operator may drive the telescope manually. If

the joystick interface hardware is malfunctioning, it should be fixed before attempting to run the Real-Time System. Effective use of the Real-Time System will be quite hampered if the manual mode of telescope control is not available.

The error message that will appear is -

HARDWARE MALFUNCTION - UNABLE TO PRIME JOYSTICK CHANNEL

The program will then issue a HOLD, which will stop the running of the Telescope program.

4. Telescope Input. The computer reads the telescope position five times a second. Whenever the telescope position is read, the channel status must first be checked to be sure that the telescope data is not changing. If after 60 tries, the telescope channel status is still bad, the following message will appear:

UNABLE TO READ FROM TELESCOPE (60 TRIES)

The program will then be put into HOLD. When the hardware condition generating the error has been fixed,

/TDR/R

may be entered at the computer teletype in order to continue.

Once the status goes good, the computer will attempt to prime the telescope channel if it has not already been primed. For the B telescope, this is trivial. For the A, however, it is not. If there is a problem and the proper data cannot be found, a message will appear and the program will HOLD. There is no recovery from this condition other than to correct the hardware problem generating the error. The message appears as follows:

HARDWARE MALFUNCTION, CANNOT PRIME TELESCOPE CHANNEL

Assuming that the telescope channel can be read, the computer checks the telescope status word. A number of conditions are reported, and the status of each is checked on each cycle. If a status bit indicates an error condition, an error message is written on the ADDS. Subsequent error messages are suppressed until another 15 minutes have elapsed. Should the status go good and then bad again, however, the message will appear before the 15 minutes have elapsed. A hardware problem that causes the status bit to flicker on and off can therefore result in a large number of messages appearing on the ADDS terminal.

Following is the list of the messages produced by error conditions as signalled by the status word.

HORIZON LIMIT REACHED - The telescope is in the stops at the horizon. The safety mechanical stop of the telescope is activated at 9.5 degrees, ± 0.5 degree. When the status bit indicates this condition, this message appears. The software, however, should catch the telescope before this happens. At an elevation of ten degrees, the software prints out the message -

TELESCOPE ELEVATION TOO LOW - IS STOPPED

When the telescope rises to a higher elevation following that, another message appears -

TELESCOPE IN MOTION AGAIN

WEST LIMIT REACHED

- These two messages indicate that the cable wrap

EAST LIMIT REACHED

limit has been reached in the indicated direction. To clarify this, an additional message appears -

CABLE WRAP LIMIT REACHED

As long as the telescope is driven in the correct direction, it will resume motion without assistance in the dome.

RA/DEC GEARS NOT MESHED - This message should be taken literally!

LOCAL/COMPUTER SWITCH ON LOCAL - This message indicates that the computer is in the local mode when it should be remote mode. As the switch is under computer control, this message should not occur and probably indicates a problem in the interfaces.

BOLLER AND CHIVENS CLOCK ON - Clock pulses are coming from the Boller and Chivens hardware instead of the computer interface logic. This requires hardware remedial action. The message will occur for Telescope A only.

SIMULATION ENABLED FOR TELESCOPE INPUT - The hardware simulator of the computer has been left enabled to send data to the computer. The computer is therefore unable to send data to the telescope. The switch setting in the dome should be changed.

SIMULATOR ENABLED FOR TELESCOPE OUTPUT - The simulator is enabled to read data from the telescope. The computer is not locked out, but the switch setting in the dome should be corrected.

DOMES IN LOCAL MODE - The computer enable switch for dome control has not been switched to the computer enable setting.

TELESCOPE IN COMPUTER INHIBIT MODE - The enable switch for the computer to control the telescope has not been set.

Once the telescope positional data is read in, the ID bits on it are checked to verify the integrity of the data. If an error is found, the telescope position is read again. The computer will try three additional times to obtain a valid set of data. The error message generated for this type of error is -

***TELESCOPE INPUT DATA LATCH ERROR...DATA=0xxx 1xxx 4xxx 5xxx 8xxx
where xxx represents three data digits.

If this message occurs, the data should be shown to a hardware maintenance person.

5. Telescope Output Channel. With the advent of the microprocessor, the computer must check status on the telescope output channel also. If the status does not go good within a reasonable length of time, the program prints an error message:

UNABLE TO SEND DATA TO TELESCOPE (60 TRIES) /TDR/TDR HOLD<
The program then holds. Once the condition is corrected (pushing Reset/Start on the microprocessor has been known to fix this condition on the B telescope), the following may be entered at the computer teletype to resume running the system:

/TDR/R

APPENDIX

BUTTON LOCATIONS AND FUNCTIONS

Joystick Button Panel

The functions of the buttons are described in clockwise order, starting from the lower left.

INIT/SIGNOFF - Reinitialize or sign off from Real-Time System.

RECORD - Print telescope position and rates on line printer.

CALIB POS - Set the telescope registers when calibrating. Used in the Calibration Check sequence to signal that the star is on boresight.

HOLD SCAN - Hold current scan offsets. Effective only when the SCAN button is on.

INTEGRATE - Scan in the Step/Track mode instead of the Step/Stare mode. Used only when SCAN button is on.

JOY RATE SAV - Save the current rate of the telescope. Effective in the joystick mode only.

JOY RATE RSTR - Restore the last rate that was saved by push of the JOY RATE SAV button. Effective in the joystick mode only.

CALIB RATES - Sets the null position of the telescope rates to the current rates. The telescope must be stopped before pushing this button!

STOP - Stop the telescope. That is, put it into sidereal drive.

INVERT - Invert the direction that the joystick drives the right ascension axis. Effective in joystick mode only.

COARSE - Enable joystick mode. If no other joystick rate selection buttons are on, the rates will vary from 0-3000 arc seconds per second depending on the displacement of the joystick.

MEDIUM - Reduce the coarse joystick range of rates by a factor of ten.

Effective only in the joystick mode.

FINE - Reduce the coarse joystick range of rates by a factor of 50.

Effective in the joystick mode only.

ADD OFFSET - Add the last offset stored by the SELECT OFFSET button to the current Main Pointing Sequence pointing output for the telescope.

This button is used in conjunction with the SELECT OFFSET button to add an operated-specified offset to a target that is tracking with ephemeris-generated rates.

SLEW - Slew the telescope in the direction indicated by the joystick.

Effective in the joystick mode only.

SELECT OFFSET - Selects the current target offset by computing the difference between the predicted target location and the current telescope position.

FREEZE - Freeze the current telescope rate. Effective in all modes, but will not override the Stop button.

TRACK - Drive the telescope under the control of the Main Pointing Sequence.

RATE JOYSTICK - Interpret joystick displacements as additions to the current telescope rate instead of as determinants of it. Effective in the joystick mode only.

TARGET-ON-BORESIGHT - Mark current telescope position as a metric data point. The data will be printed on the line printer and written on magnetic tape and on the observation file disc.

18-9-5962



TARGET-ON-BORESIGHT



JOYSTICK PANEL

ADDS Button Panel

The button function description for this panel will be described from left to right starting with the upper left button.

ALARM - A red button that lights up and squeaks when an alarm condition is detected. To acknowledge, push the button; the light and the audible alarm will be turned off.

VEC - Run the Vector Element Comparison program to find all satellites within five degrees.

SAT EPH - Select next satellite.

FIX PT - Select next fixed point. Input may be in right ascension and declination or azimuth and elevation.

CAL - Invokes the calibration sequence. A Fixed Point must precede it. The user will be requested to push the CALIB POS button to actually set the registers.

CAL CHK - Drives the telescope to six bright stars in the area and computes differences between actual and predicted positions. Uses CALIB POS button as the operator signal that star is on boresight.

SEARCH - Box scan program. Requests input from operator to determine scan parameters.

ALONG ORBIT - Along orbit scan. Requests input from the operator to determine scan parameters.

SCHEDULE - Activate the Dynamic Satellite Scheduling program, which will suggest the next satellite to track.

DIAG PRT - Generate diagnostic printout about telescope behavior.

QUERY SCAN - Print the progress report on the scan pattern being used.

TGT BELOW 15 DEGRS - Current target location is below 15 degrees.

Button light flashes.

LAST FOV - If scanning, return to last field of view. Effective only when SCAN button is on.

MAG TAPE REC - When on, magnetic tape recording will be done.

OVERRIDE - Low elevation override selection for Telescope Control program.

Telescope elevation limit in software will be reduced from ten degrees to three.

SCAN - Begin the specified scan pattern.

ALARM										VEC	SAT EPH	FIX PT	CAL	CAL CHK	SEARCH	ALONG ORBIT	SCHED- DULE
											DIAG PRT	QUERY SCAN	TGT BELOW 15 DEG	LAST FOV	MAG TAPE REC	OVER- RIDE	SCAN

ADDS PANEL

18-9-5963

SOI RECORD						
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SOI BUTTON PANEL

SOI RECORD — Records SOI data for later use in optical signature studies.

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GEODSS	real-time	metric data									
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <p>The following guide describes the GEODSS Real-Time and simulated system from the standpoint of the operator. Included are descriptions of system messages, operator inputs and options, and error conditions and recovery procedures. Much of the system is controlled by programmable buttons, and diagrams of their locations and functions are included in the appendix.</p> <p>The Real-Time System runs on a MODCOMP IV computer with 128K of core. It gives the operator control of one of two 31-inch optical telescopes in the automatic search/track or manual mode. The automatic mode are used for locating and tracking satellites. To aid in finding them, various scan patterns are available, which may be superimposed on the basic tracking of the telescope. The operator may also control the telescope manually at rates ranging from a few seconds of arc to four degrees per second. Calibration and calibration checking are two other features of this system. Magnetic tape recording, line printer output and a metric observation file log the metric data. Target identification assistance is provided by a program that lists all known satellites within five degrees. A satellite scheduling program may be used to automate scheduling. An SOI data collection capability is also available.</p>											

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